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Understanding N2O sources and sinks with laser based isotopic analysis

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Nitrous oxide (N2O) is a potent greenhouse gas and the strongest ozone-destroying substance. The main emissions of N2O are linked to different microbial processes, therefore the sources are disperse and highly variable, complicating the development of effective mitigation strategies. Isotopic measurements have great potential to unravel spatial and temporal variations in sources, sinks and chemistry of N2O. Recent developments in quantum cascade laser spectroscopy (QCLAS) [1] allow both the intermolecular distribution of 15N substitutions ('site preference'; 15N14N16O versus 14N15N16O) and the oxygen isotopic composition (d18O) of N2O to be measured in real-time and at high precision of <0.2 ‰ [2]. Additionally, N2O isotopic analysis by QCLAS has demonstrated excellent compatibility to the standard technique isotope-ratio mass-spectrometry [3].
In a number of laboratory and pilot plant studies we investigated the isotopic signature of distinct microbial and abiotic N2O production and consumption pathways in soil and aqueous solution [e.g. 4]. Specific pathways were favoured by selection of the nitrogen substrates and process conditions and their isotopic signatures identified by real-time laser spectroscopic analysis. Results from our laboratory studies are in accordance with pure culture experiments and can therefore be applied to other ecosystems.
Recently, high precision isotopic analysis at ambient N2O is also feasible by combining laser spectroscopy with automated preconcentration [5]. The field deployment was demonstrated by real-time monitoring isotopic composition of N2O emissions from an intensively managed grassland in central Switzerland for three months. The responses of the N2O isotopic signatures were analysed with respect to management events and weather influences [2]. In a follow-up project we intend to combine real-time N2O isotopic analysis at a tall tower in central Switzerland with atmospheric transport simulations and a biogeochemical model of surface fluxes of N2O isotopomers. The working hypothesis is that this approach will allow us to quantify regional N2O sources, identify emission hot spots, and constrain source processes, which will be of upmost importance for developing targeted mitigation options.

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